M&S Means Modeling and Simulation — *Not* Methods for Simulation

Optimization Model — Complement, Alternative, and Synergistic Partner to Simulation

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A recent issue of *Program Manager* devoted to Modeling and Simulation (M&S) presented a wide range of applications that highlighted the usefulness and ubiquity of these computer-based techniques.[1] From the articles, clearly the Department of Defense (DoD) is a leader within the realm of M&S.

The 1990s have brought with them a great appreciation for the value and cost effectiveness of modeling in acquisition, training, and analysis. Unfortunately, many people within DoD equate modeling *with* simulation, ignoring the full potential of the other capabilities. By contrast, the private sector is well aware of, and fully exploits a full range of modeling techniques.

In this article, we emphasize that simulation is only one technique within the set of available modeling tools. Furthermore, other model forms, notably optimization, should often be used as a complement, alternative, and synergistic partner to analytical simulation.

Why *Does* DoD Emphasize Simulation Over Other Models?

Perhaps the simplest explanation as to why the DoD places so much emphasis on simulation models is because they are easy to understand, and have a long history of successful use by warfighters. Simulations allow the analyst to abstract reality in a logical, time-progressing manner. Indeed, the level of intuitive understanding facilitated by simulation allows any amount of human participation – from a pure training application where humans "run the show," all the way to a pure analytical application where the soldier's role embodies only one of many mathematical interactions.

Human participation gives simulations the advantage of familiarity over other modeling techniques, since most commanders have been exposed to the use of simulators as training devices. For many, the word "simulation" evokes the thought of climbing into a large, hydraulically supported box, whereupon some sadistic "old head" gets to dial-in a sequence of nerve-wracking disasters.

People who use simulations as analytical tools are keenly aware of this mindset. Fortunately, they were able to participate in fuller measure as the emphasis on simulations continued to increase over the past decade. Without the well-understood training application, the recognition (and budgets) of analytical modeling might still be unrealized.

Simulations also lend themselves to distributed interaction. The very first objective of the Defense Modeling and Simulation Office (DMSO) is to develop a common technical framework for M&S, so as to allow interactions across agencies and models.[2] The advent of object-oriented simulation languages facilitates this interaction. Specifically, object orientation allows each logical piece of a simulation to be written as a separate module of computer code. In this way, the development, and even the processing of individual modules can now be the responsibility of organizations that have expertise in each of the sub-systems being modeled.

For example, an F-16 software "object" (developed by the Air Force) can be "plugged into" a model used by Marine Corps modelers in a simulation that might otherwise crudely approximate Air Force assets. Thus, simulations are perfect candidates to break out of the traditional stovepipe models that do not exploit the efforts of other organizations.

Finally, simulations allow the modeler to incorporate an enormous amount of modeling detail, as well as include a corresponding amount of scenario uncertainty. From the standpoint of realism, these features are indeed useful.

Furthermore, a high capacity for complexity allows the analyst to respond to stakeholders who challenge a model's validity based on a perceived lack of detail with respect to their particular, and perhaps parochial activities. To be fair, many military models *must* be complex, and must also incorporate the "fog of war" (otherwise known as uncertainty).

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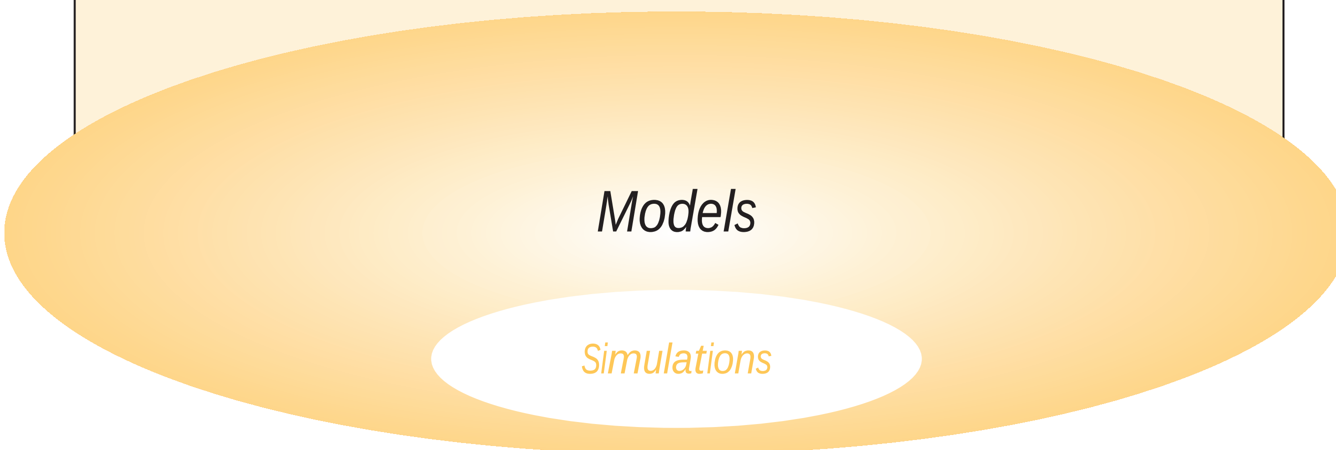
Models cover a broad spectrum of computer-based techniques; simulation is only one of many model types. Many DoD agencies have focused almost exclusively on simulation, although optimization models often present an equally effective capability.



Simulations can easily represent both of these attributes.

Why Shouldn't DoD M&S Efforts Focus Only on Simulation?

Given the advantages cited above, why *should* DoD consider alternate approaches when designing an analytical model of a complex system? Unlike the military, the private sector frequently relies on optimization models for key decisions. What benefits do optimization models (and other types) bring to the analytical decision process?

Perhaps foremost among the reasons to consider optimization models is the need to observe complex decision alternatives from multiple perspectives. Models may aid many important DoD decisions, but decision makers (rightfully) do not completely trust any of their models. Confidence in analytical recommendations can be greatly enhanced when two fundamentally different model types are considered. Thus, optimization models provide a *complementary* capability to simulations.

By their nature, optimization models describe "what's best?" as opposed to simulation models, which describe "what if?" As an example, consider the modeling of a strategic airlift deployment. A large U.S. Air Force simulation proceeds by loading cargo onto the first available aircraft, which is then routed according to a pre-selected prioritized list.[3]

In contrast, an optimization model of the same deployment is given aircraft and routing *options* for all cargo, and is left to schedule the *best* combination of aircraft and route for each cargo.[4] The two approaches are fundamentally different. Although the simulation describes how much cargo an existing deployment plan can move, the optimization will often provide insight as to how to *improve* that plan, or concept of operation. Consequently, optimization models provide a useful *alternative* to simulation.

Each model type has a significant strength; simulations can model highly detailed scenarios, while optimizations employ a scenario's resources more efficiently. This suggests a two-stage approach. An optimization model can be used as a simulation pre-processor to make important resource selection and scheduling decisions.

In turn, those decisions may be checked for feasibility by a more detailed, and perhaps stochastic (probabilistic) simulation. The simulation can then adjust the plans made by the optimization in order to accommodate its higher level of detail. In this way, the two modeling approaches are used *synergistically* – each offering its strengths to produce more accurate, and more insightful recommendations.

Optimization Models — Great Potential Benefit

The widespread use of M&S discussed in *Program Manager* provides incalculable benefits to DoD. However, part of the continued success of M&S relies on our awareness of the full range of available modeling techniques. Despite the overwhelming emphasis on simulation for modeling complex systems, optimization models have great potential benefit, and should be used in concert with existing simulations.

It is incumbent upon the acquisition community to be aware of this modeling capability *as a complement, alternative, and synergistic partner to simulation.*

REFERENCES

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